Chapter 2 – Concepts of Mass and Energy in Western Civilization

1) Matter and Motion

Throughout the remainder of this thesis, I will be making increasing references to basic concepts of physics -- especially, the concepts of 'matter' and 'energy' -- so it is appropriate at this point to go into some detail regarding the meaning of these and other related terms. I will avoid a technical discussion, limiting my approach to the philosophical implications of these concepts. Let me also add that I will take these two concepts in a relatively straightforward manner, as it is not my intention to make a deep metaphysical inquiry into what precisely we mean by the terms 'matter' and 'energy'. I treat these concepts essentially as modern science does, presuming that there is some meaningful sense in which we can quantify them and their effects. My main intention is to develop the philosophical significance of the basic elements of the physical world as it pertains to the emergence of the phenomenon of 'mind' in particular and to the Participatory Worldview in general.

The universe of the contemporary physicist is a world of material objects, and of energy. Matter and energy exist in a realm of 3-dimensional space, and they endure with varying degrees of stability throughout time. Matter and energy have been unified by relativity theory into a single substance, 'mass-energy'. Space and time have been unified, also by relativity theory, into a single 4-dimensional entity, 'space-time'. Thus, the modern physicist sees a universe that is quite simple and elegant: mass-energy (in various forms) moving through space-time.

This is the essence of the materialist worldview. Nothing exists except mass-energy, and space-time. Anything else, and anything not ultimately describable in terms of these elements, is unreal.

To better understand the full implications of a mass-energy universe, I will first explore the history of these concepts. The study of matter and energy goes back to the earliest days of our civilization. The ancient Greeks were among the first in human history to take a deep, rational look at the world around them, and to attempt to draw some general conclusions. In striving to understand the natural world, the Greek philosophers sought out the *essential principles* of nature; they asked the most basic questions; and they sought to unify the diversity of phenomena into a single comprehensive theory or vision.

Their line of inquiry was shaped by the primordial worldview into which they were born. This determined the starting point. As with many early cultures, the Greeks inherited a worldview of diverse material objects ruled and influenced by a pantheon of gods. This worldview seemed to account for human and natural events in a semi-comprehensible manner. Then around 600 BCE certain Greek thinkers began to depart from this worldview and ask different questions. They took an intellectual 'step back', and adopted a new perspective; they saw a world that consisted, in its essence, of *things that move*.

Once seeing the cosmos as composed of 'things that move', two central lines of investigation open up. One naturally wants to know: (1) what is the nature of 'things': what do they consist of at root, what are their properties, and how do they acquire these properties; and, (2) what is the nature of 'movement': how and why do things move, and what is the nature of the interaction between any such 'motive force' and material objects. And in fact, much of Greek philosophy is dominated by these two general lines of inquiry. Certainly *physis* (physics, or the study of nature) was, and even ethics was also to a large degree shaped by one's view of the natural world; as, for example, F. Sandbach said of the Stoics, "The question of right conduct could not be settled without understanding the relation of man to the universe." (1975: 14). Even logic, the third traditional branch of philosophy, was developed in large part to make clear one's arguments about *physis*.

This study of 'things that move' was the first step in the articulation of a new 'logos' worldview. This was a rational view of the world, based on basic principles that could be grasped by ordinary mortals. Some of the mystery and capriciousness of the mythic worldview had faded, and in its place was a worldview in which human kind was more naturally integrated. Humanity was seen as a more fundamental part of the whole cosmic picture, not merely as a resident of the 'mortal plane', while gods ruled on high from the 'spiritual plane'. Granted that the mythic world had its own sense of integration, but this was in a relatively naïve and innocent sense. Logos represented a whole new direction in human thought, one in which humans were rationally integrated into the very processes of the universe. This, I claim, was the first step on that detour of thought that led to the Mechanistic Worldview, and which even now is evolving into the Participatory Worldview.

The fundamental ontological status of 'things' and 'movement' formed the basis of the emerging scientific worldview. Robert Boyle, writing in 1674, said, "I…observe that there cannot be fewer principles than the two grand ones of our philosophy, matter and motion." (Matthews, 1989: 113). This situation has continued even through the present. Our modern mechanistic worldview, the one that sees a universe consisting solely of 'mass' and 'energy', has clear parallels to this ancient Greek vision of 'things that move': 'things' are composed entirely of mass, and 'movement' is the essence of energy. So in a sense, we still have not moved beyond this primitive view. But the Participatory Worldview is clearly becoming articulated, and I see the ancient Logos view as an entirely appropriate place to start.

2) *Philosophia Materia* — Historical Perspectives

Let me begin with a brief examination of 'matter'. Matter, originally, meant wood. Wood was the prototypical 'stuff' which people used to make things. The word 'matter' comes from the Latin *materia*, which had as its root meaning 'the hard inner wood of a tree'. *Materia* itself came from the even older word *mater*, or 'mother': the inner wood was considered to be the mother of the new outer growth, which was relatively soft and pliable. Thus, *materia* had two essential characteristics: it was a *living* substance, and it was a *generative* substance; both of these notions are highly evocative, and are relevant to the discussion at hand. Over time it expanded its usage, and came to denote not just wood, but any generic material, and this is the meaning that was carried into English from the late 1500's on.

Interestingly, the Greeks also had a word for 'substance', and this word also meant wood: *hyle*[1]. One can clearly see why this is a cross-cultural occurrence; most every early human society had access to wood, and it would have been a near-ideal substance for making things from. As in Latin, the meaning of *hyle* grew to encompass a broader meaning, roughly equivalent to our 'stuff', 'substance', or 'matter'. In Greek philosophy, Aristotle was the first to refer to *hyle*, meaning both 'that out of which something has been made', and 'that which has form'. *Hyle* has a very small legacy in English. In prefix form, we have such words as hylism (meaning 'matter as the original principle of evil', a doctrine attributable to Plotinus), Hylidae (a family of tree frogs), hylopathism (doctrine that all matter is sentient – related to pansensism, as discussed in Chapter 5), and hylozoism (doctrine that all matter is alive – more on this later). As a root word, it can be found in certain chemical terms, such as methyl, which is a combination of the Greek words *met* (wine) and *hyle* (wood), hence the term methyl alcohol (an alcohol distilled from wood) means literally, 'wood-wine'.

Philosophically, matter was important because it represented at least one fundamental aspect of reality. A theory of matter, in general, was therefore a theory of reality, or at least a portion of reality. The early Greeks explored two general lines of inquiry relative to matter: the essential, defining characteristics of matter (those that distinguished it from 'non-matter'), and, the type of substance or substances that matter consisted of.

This inquiry was linked, especially with the pre-Socratic philosophers, to another concept, *arche*. An *arche* is a 'first principle', and in particular, the first principle of the cosmos. This principle typically centered on the nature of the *materia* that composed physical reality. For example, the earliest pre-Socratic philosopher, Thales (625-545 BCE), argued that the *arche* was water, and that therefore all material things were composed of, or could be reduced to, water.

Most of the pre-Socratics, with the notable exceptions of Anaxagoras and Empedocles, argued that the *arche* consisted of a single basic entity or substance; they were ontological monists. If the *arche* was a single substance, then clearly 'matter' was to be viewed, at root, as this same substance. After Thales, for example, there was Anaximenes (585-525 BCE), who held that the *arche* was air. Heraclitus (505-450 BCE) made the claim that fire was the first principle of the cosmos.

Anaxagoras, as I mentioned in Chapter 1, put forth 'mind' as the *arche*. Mind for Anaxagoras was not the constituent of matter, but rather the guiding and organizing force. He held that matter consisted of an infinite number of substances, and that each was present in some small degree in every material object. Thus, Anaxagoras was the first to propose a pluralistic worldview, one with both (infinitely many) substances, and with the separate over-arching force of mind[2].

Empedocles, an older contemporary of Socrates, also argued for a pluralist view, though a more concrete one. He postulated a cosmos consisting of four elements – earth, water, air, and fire – interacting via two non-material forces, which he called "Love" (attraction) and "Strife" (repulsion):

> Hear first the four roots of all things: bright Zeus [fire], life-giving Hera [air], and Aidoneus [earth], and Nestis [water] who moistens the springs of men with her tears (frag. 6).
>
> And these [elements] never cease changing place continually, now being all united by Love into one, now each borne apart by the hatred engendered of Strife... (frag. 17).

These advances by Anaxagoras and Empedocles were significant developments; they were the first clear moves toward a modern conception of physics -- a universe of matter and of force.

As mentioned above, in addition to the type of substance comprising the *arche*, there was the question of its defining characteristics. Matter had two essential characteristics: first, it occupied space. Matter was a solid, impenetrable substance that completely filled some region of space. Matter defined as 'full space' has a number of logical implications, as Capek (1961: 55) explains: "If matter is full space, then its constitutive elements must be by their own nature impenetrable, indivisible, indestructible, rigid, and homogeneous." And in fact, this was the basic view of most pre-Socratics.

The second core property of matter, accepted by most all of the pre-Socratic philosophers, was this: *matter, to them, was alive*. This is the theory known as 'hylozoism', from *hyle* ('matter') and *zoe* ('life'), and the Greeks philosophers are rather infamous for articulating it. It was not merely some incidental quality, but was central to their view of the cosmos. Consider, for example, the early Milesian philosophers (including Thales, Anaximander, and Anaximenes), who in the 6th century BCE were the first to articulate the new Logos worldview. In summarizing the three key qualities of Milesian philosophy, Guthrie observes that "[The Milesian] view of nature was rational, evolutionary, and hylozoist." (1962-81, vol. 1, p. 140). He continues: "For the Milesians the union of matter and spirit in a material substance…is an assumption that raises no doubts and calls for no argument or defense." (p. 145). Later pre- and post-Socratics held related views, as we shall see. In spite of the infamy of hylozoism, this aspect of their philosophy is quite misunderstood, under-analyzed, and under-appreciated. The fact that even Plato, and perhaps Socrates as well, held similar views would likely come as a surprise to many readers; even Aristotle, whose theory of matter is clearly non-hylozoist, made some interesting claims about the presence of soul in the natural world. This issue requires much further elaboration, which I will detail in Chapter 5.

The view of matter as alive was challenged first of all by the Atomists -- Leucippus (485-425 BCE) and Democritus (460-370 BCE) -- and then given a major setback by Aristotle (384-322 BCE). The Atomist philosophy of nature held that small, indivisible atoms (*a-tomos*, meaning literally 'not divisible') were the essence of matter, and that these atoms swirled about in the void of empty space[3]. Atoms were found in a variety of types and shapes, and this variation accounted for the diversity of things.

In the traditional view, atomism is a purely materialist, virtually mechanistic ontology. However, there are some interesting claims to the contrary even here. Tallmadge, for example, has noted that Leucippus may well have inherited something of the Ionian hylozoist tradition: "It is not entirely improbable [that] the Atomism of Leucippus should be considered a species of hylozoism." (1944: 186). This view is supported by the writings of Democritus, as I will show later.

Aristotle was different. His inquiry and conclusions deeply undermined the hylozoist view. He equated matter with potentiality, that is, of having the capacity to receive a given form. Matter itself was neutral and inert. Aristotle supported the four-element theory of Empedocles[4], but modified it such that each element consisted of both matter and form. The 'life force' present in animals and plants was seen by him as an 'essential form' of their being; this was his definition of soul. Thus it was not an essential property of matter in general, and therefore matter as such was not 'alive' as it had been for most of his predecessors.

Thus, the legacy of ancient Greece produced *two fundamentally opposing views of matter*: the Aristotelian view of matter as inert and lifeless, and the hylozoistic view of matter as alive. As I mentioned, the latter view finds support in the writings of Plato. In his *Timaeus* (which served as the central Platonic text for much of the Middle Ages), Plato articulates the concept of the 'world-soul', the animator of the universe. Plato viewed the world/cosmos as "a truly living thing, endowed with soul and intelligence." (*Timaeus*, 30c). More importantly, individual objects possessed their own independent souls or minds. In particular, heavenly bodies, including the sun and the stars, were explicitly argued to possess souls[5].

Plato's conception of the animated universe, and by implication everything in it, was taken up by the Stoics. Circa 2nd century BCE, philosophers such as Zeno of Citium and Chrysippus developed a theory of matter based on Empedocles' four elements of earth, water, air and fire (though they largely abandoned his reference to Love and Strife). They viewed two of the elements, fire and air, as 'active' matter, and the other two as 'passive' matter. All material objects were composed of some combination of active and passive matter. This dual aspect approach has an interesting connection to our dual modern concepts of energy (active) and mass (passive).

The Aristotelian view of dead matter was carried on by the school of Scholasticism, which dominated philosophy for much of the Middle Ages. The medieval alchemists largely followed the Aristotelian conception, as they strove to 'fulfill the potential of matter' by transforming it into precious metals. All along, though, there was a persistent counter-movement of Platonists who kept alive the view of matter, and the universe, as endowed with soul and life.

Descartes continued to view matter as passive and inert; he famously defined it as a *res extensa*, something completely distinct from mind. Leibniz criticized this view, arguing that passivity could not account for change, action, structural unity, or causality. His response was to postulate the existence of 'monads' as the fundamental reality, which were active and even mind-like (i.e. self-moving) in nature. Leibniz's monadology was an essentially Platonic response to the dominant Aristotelian view.

Newton was of course famous for his mechanistic conception of the world, and it is commonly believed that he too viewed matter as something inactive and lifeless; surprisingly, though, certain comments by him indicate that he had doubts about this. In one rather backhanded but astonishing comment, he notes that "We cannot say that all nature is not alive" (McGuire, 1968: 171); more on this view of Newton's later.

His opinion on hylozoism notwithstanding, Newton made a quantitative breakthrough in defining the concept of *mass* as 'quantity of matter'. Mass was a common measure of all material objects, and was the critical element of his new theory of gravitational force. Mass was manifest to us as 'weight', but Newton recognized that weight was a function of Earth's gravity. Mass, on the other hand, was an 'independent' quality; it measured the amount of 'stuff' present in a given object. And it inherently produced its own gravitational field.

In the 18th century Kant reinforced the view of 'dead matter'. He played with the idea that matter may have some inherent activity or sensitivity, but ultimately ruled this out as inconceivable. Kant wrote, "[T]he possibility of living matter cannot even be thought; its concept involves a contradiction, because lifelessness, *inertia*, constitutes the essential character of matter." (1790: 242).

Interestingly, at about the same time Boscovich (1711-1787) began his formulation of matter as virtually 'immaterial'. In what would later become known as *dynamism*, Boscovich theorized that atoms of matter were essentially zero-dimensional points that were manifest entirely as a field of force. In effect, matter was nothing more than this force itself, and experimental evidence backed this view. This was the first modern step towards a conception of matter as equivalent to energy.

The "new physics" of the 20th century – including relativity and quantum physics – radically altered many of the ancient views of matter. Mass was no longer seen as indestructible, unchanging, and invariant; Einstein showed total mass of an object to be a relative concept, dependent upon one's frame of reference. Furthermore, the passive and active were unified when Einstein showed mass and energy to be fundamentally interchangeable. It became more appropriate to speak of 'mass-energy' as a single substance. Quantum mechanics described particles not as hard, impenetrable spheres, but rather as fuzzy clouds of probabilities; a particle like an electron could effectively 'exist' over a relatively large region of space, and one had varying degrees of likelihood of detecting it at different locations. Associated with this was the idea that atoms and other sub-atomic particles have a *dual nature* — they can be viewed as *particles* or as *waves*. This insight, attributable to DeBroglie, further emphasized the equivalence of matter and energy.

Advances in high-energy test equipment allowed researchers to push further inside atomic particles, and they are now able to distinguish sub-particles, called 'quarks', inside protons and neutrons. The current fundamental theory of matter, though aesthetically and intuitively unsatisfying, does an exceptional job of predicting physical phenomena. In the current standard model all matter is composed of two types of particles, 'leptons' and 'quarks':

1) <u>Leptons</u> — 6 kinds (includes the electron, and three variations of neutrinos)
   * considered to be "point-like, without structure"

2) <u>Quarks</u> — 6 kinds (up, down, top, bottom, strange, charm)
   * quarks are constituents of heavier particles like protons and neutrons, each with 3 quarks

In addition to these so-called 'mass particles', there are also 'force particles' which constitute the remaining aspect of physical reality; these are described in the following section. Physicists are currently seeking a more comprehensive and more satisfying theory of matter — 9-dimensional string theory being a hot candidate — to explain why these 12 particles are required, and perhaps how they derive from some simpler set of particles or forces. One thing is certain: this standard model is assuredly Aristotelian -- these particles are unquestionably without life, without soul, without mind.

However, the tag 'inert' has somewhat fallen by the wayside, certainly since Einstein equated matter with energy. Matter is seen as 'energetic', 'active', and 'dynamic'; the proton, for example, spins on its axis some 10^{22} times per second. And again the DeBroglie wavelength concept emphasizes the oscillatory, dynamic nature of all elementary particles of matter. Thus, the concept of *energy* has become equi-primordial to that of matter, and it has an equally long and intriguing history.

3) *Philosophia Energeia* — Historical Perspectives

With this background on the concept of matter, we can quickly trace the development of energy. The earliest philosophical reference to energy comes in the form of related terms, like 'motion' and 'force'. As early as Thales we find the idea that the capability of self-motion or self-energization is connected to the possession of a soul -- where 'soul' is interpreted as nearly interchangable with 'mind'. Thales famously noted that a magnet must possess a soul/mind, since it has the power of movement. This is our first indication that mind is somehow intimately and deeply connected with the concept of energy.

Heraclitus' *arche* of fire has obvious connections to energy. Fire/energy is not only the First Principle of the cosmos, but it is literally the fundamental stuff of the material world; "All things are exchanged for fire, and fire for all things" (frag. 90, in Smith, 1934:11). This fire is not the ordinary fire of the hearth, but is rather "an ever-living fire" (ibid), a life-giving energy, that is the root of everything. In the same vein, Heraclitus claimed that *'panta rhei'* – everything flows.

Anaxagoras reestablished the connection between mind and energy; mind as the *arche* was the ‘organizing force’ of the cosmos. At about the same time Empedocles was articulating his theory of the two fundamental forces, Love and Strife. In both cases we see a striking similiarity to modern-day views: of a universe of substances moved and organized by a small number of fundamental forces.

But in these pre-Socratic writings we do not find explicit reference to the word ‘energy’; the first usage doesn’t appear until the work of Aristotle. The Greek word he used was *energeia*, composed of two roots, *en-* ('at') and *ergon* ('work', or 'deed'). Energy may thus be defined as the capacity or ability to do work. Aristotle used the term to mean, generally, 'activity' or 'power of action'.

This definition, however, begs a question: what is 'work'? Work in the ancient, folk sense means simply, 'something done', 'some change effected'. Change, in turn, requires *movement*, displacement. This is our common sense notion — physical, manual work always involves moving something. This gets back to my original depiction of the Greek cosmos as consisting of 'things that move' — movement being activity, *energeia*, energy.

Thus, the philosophy of energy was, at the beginning, a philosophy of movement. The critical issue for the early philosophers was: does a particular moving object or substance *move itself* (i.e. self-generating), or is it moved by something else? Self-moving objects to Plato were alive, and endowed with a soul. Guthrie, speaking on the Platonic concept of soul, states that it is "the self-moving principle which imparts its own motion to otherwise inert body, thus making it animate." (1962-81, vol. 4, p. 420) In Plato's own words:

> "[W]hen an object moves itself, [we are] to say that it is 'alive'… [W]hen we see that a thing has a soul, the situation is exactly the same… We have to admit that it is alive." (Laws X, 895c)

> "[T]he definition of the thing we call soul [is] 'motion capable of moving itself'." (Laws X, 896a)

> "[S]oul, by virtue of its own motions, stirs into movement everything in the heavens and on earth and in the sea." (Laws X, 896c)

So for Plato, *'soul' is the cosmic principle of motion*, of energy, that drives all movement within the universe. Human beings, of course, have long been believed to be 'energized', animated, by some presence that was called 'soul'; Plato and other philosophers extended this concept to everything that moved — fire, wind, the oceans, the stars and planets, the cosmos as a whole.

Aristotle held to a much more limited conception of soul. Only certain things possessed a soul, including the Prime Mover of the cosmos, certain celestial bodies (surprisingly enough), and self-moving organisms (the things that we today call 'alive'). People and animals had souls, but so too did plants: "It seems also that the principle found in plants is also a kind of soul;" (*De Anima*, 411b27) — Aristotle saw the life processes of plants as being sufficiently similar to those of animals to consider them likewise ensouled. All other physical and cosmic motion was driven, ultimately, by the primordial "unmoved mover", God. Aquinas would eventually adopt this Aristotelian view. He conceived of force, or energy, as deriving from the inexhaustible source of God, and acting independently upon things that moved.

Shortly after the death of Aristotle, the Stoic philosophers saw the need for a cosmological force that would hold the four elements together. They developed a system of philosophy in which an energetic substance, the *pneuma*, sustained and permeated all things. *Pneuma* was an intimate combination of the two active elements, fire and air. The term itself recalls Anaximenes' concept of 'air as spirit', and in fact it means something like 'breath', 'soul', or 'life'. *Pneuma* pervaded all parts of the cosmos; it bound things together into coherent wholes, and it accounted for all the various properties of things. Similar to Heraclitus, it was described as a 'creative fire', a *pyr technicon*, which creates and sustains form. Most importantly, it embodied the 'life energy' of matter, and endowed all things with a degree of spirit. Stoicism was the most well-developed philosophy of energy in the ancient world, and I will elaborate on this subject – especially the panpsychist vision – in Chapter 5.

The concept of energy underwent very little change for several centuries, until it began to take on its modern, physical meaning in the early 17th century. Galileo and Simon Stevin shifted the focus back to 'work', and they were the first to describe it precisely in terms of *force*. Clearly, in order to get something to move, we must apply a *force* to it. This raises a question as to the nature of force. The modern dictionary definition is "an agency or influence, which when applied to a body, results in an acceleration [i.e. movement] of that body". In other words, 'force' is that which causes motion. For Plato, soul was the one and only force; it was the *original* force. Galileo and Stevin were not concerned with what originated movement. They accepted force as any push, pressure, or impact that got something to move. Thus, if I push (lift) a heavy object up into the air, I am doing 'work'. The longer I apply a force, the farther the object travels, and the more work I do. They therefore defined 'work' as 'force times distance'. This is equivalent to our modern equation: $W = F * D$.

Into the 1600's, there emerged a debate between Descartes and Leibniz as to the proper definition of the energy of a moving object[6]. Descartes defined it as 'mass times velocity' (mv), which we today call *momentum*. Leibniz called it the *vis viva* ('life force'), and defined it as 'mass times the *square* of velocity' (mv^2) — essentially identical to our modern definition of *kinetic energy* (we now add a factor of '½').

Bernoulli introduced the word 'energy' into the scientific literature in the early 1700's, and this set off a 150-year confusion about the usage of the terms work, force, and energy. Part of the reason for this was technological: prior to 1800, there simply were no mechanical devices or inventions that stored or transformed energy. Watt's steam engine, and the invention of electrical motors and generators, began a more intense interest in the concept of energy itself, and the need arose to distinguish it clearly from 'work' and 'force'.

The influence of Descartes and especially Leibniz was considerable, and schools of philosophy began to emerge that were centered on the concepts of force and energy. The first of these was *dynamism*. Its chief adherent was Boscovich, who as we saw developed the position that force (again, not clearly distinguished from 'energy') was the fundamental ontological reality: mind and matter were really just various manifestations of force. This was a major advance, because here, for the first time in the modern era, a theory of energy had replaced and superseded a philosophy of matter. In other words, we now had a theory of matter that was *immaterial*. Energy had assumed a "new ontological status", superior to that of matter. Nietzsche was evidently impressed; he called the dynamist theory of Boscovich "the greatest triumph over the senses that has been gained on earth so far" (1886: 20).

Priestley (1733-1804) held a similar view, but he went further metaphysically, arguing for a panpsychist account of matter by equating matter and mind. Like Priestly, Herder (1745-1803) and Schelling (1775-1854) developed dynamist views of reality in conjunction with panpsychist theories of mind — further details on these individuals later.

In the late 1700's, Carnot argued that 'energy' could be represented *either* as $\frac{1}{2}mv^2$ or F*D. This was an important advance, because it finally, and correctly, linked the three concepts of energy, work, and force. In particular, Carnot showed that 'work' and 'energy' were really the same thing, measurable in identical terms. A simple example will illustrate this. Consider a metal spring, one end fixed, lying on a frictionless table. We can compress the spring by applying a constant force 'F' to the free end; this will cause it to compress some distance 'D', where it will stop (when the counter-force of the spring equals our applied force). Latch the spring. In applying this force F over a distance d, we have done work W = FD.

Now place some small mass 'm' at the free end of the spring, and release it. The 'energy' measured by the 'FD', stored as *potential* energy in the spring, is now converted into *kinetic* (i.e. 'actual') energy of the mass. Neglecting frictional losses, the mass will be accelerated (by the force of the spring), and will reach a velocity 'v' such that

kinetic energy = work,

So: $\frac{1}{2} mv^2 = FD$,

Or: $v = \sqrt{(2FD/m)}$

The fact that 'work' and 'energy' are the same thing is reflected in the units of measurement — both are measured in *joules*. One joule of work is roughly that required to lift a one kilogram mass by 10 cm.

By the early 1800's it was becoming clear that energy applied not only to moving objects, but to other natural processes that had the ability to produce motion. The ability of living organisms to move was seen as residing somehow in the 'energy' of the food they ate; we recognize this now as chemical energy. Electric and magnetic 'fields' were known to attract or repel objects, and thus the fields themselves must somehow embody energy. The phenomenon of heat was seen as a kind of motion. Gravity was clearly able to move things. It began to dawn on some thinkers that, everywhere they looked, they saw not so much raw 'force' as energy — that perhaps even all of nature was, in essence, energy. In 1799, Schelling exclaimed that "magnetic, electrical, chemical, and finally even organic phenomena would be interwoven into one great association…[which] extends over the whole of nature."[7].

In the mid- to late-1800's, as the study of the concept of 'fields' advanced, it was possible to envision energy with no material substrate at all. It became apparent to people such as Maxwell and James Croll that energy could exist in 'empty space', embodied in fields that permeated even a vacuum. In particular, energy could exist and move without any obvious presence of force; thus it came to be regarded as a more fundamental reality. To conceive of energy present even in empty space was a large conceptual and philosophical leap; 'non-material energy' sounded irrational, heretical, even mystical. Yet it could not be denied. Maxwell's wave equations were unquestionably confirmed.

Continuing in the line of thought originated by dynamism, some philosophers thus began to argue that not force but energy was the primordial basis of all reality. This was the doctrine of 'energeticism', and was advocated in various forms, beginning in an early form with Spencer (1820-1903), and further developed by Maxwell (1831-1879), Mach (1838-1916), and Ostwald (1853-1932)[8]. They all held that natural phenomena were simply different manifestations and transformations of energy, which was the basic physical reality. Their case was bolstered by advances in science, and especially in electromagnetic theory, where it became increasingly clear that electric and magnetic energy existed and could travel through space at exceedingly high speeds.

Energeticism found its consummation and ultimate articulation in Einstein's theory of relativity, in which he formulated the famous equation $E=mc^2$, showing that matter and energy were, in fact, fundamentally equivalent. The concept of a single entity, *mass-energy*, resolved much of the tension between competing theories of matter and the theories of energy, unifying the two concepts in larger, transcendent framework. Philosophers of science still, however, maintained an energeticist inclination, opting to view energy as the more dominant and fundamental mode of existence, rather than mass. This was clearly Einstein's view:

> Matter which we perceive is merely nothing but a great concentration of energy in very small regions. We may therefore regard matter as being constituted by the regions of space in which the field is extremely intense… There is no place in this new kind of physics both for the field and matter for field [i.e. energy] is the only reality. (cited in Capek, 1961: 319)

Russell stated the same idea in 1948, when he claimed that "it is energy, not matter, that is fundamental in physics" (1948: 291). Heisenberg held the same opinion — see his (1958: 61, 67). More recently Popper reiterated this view; "matter turns out to be highly packed energy" (Popper and Eccles, 1977: 7).

Over the course of the 20th century, modern physicists gradually developed our present conception of energy. Einstein had showed that mass, in itself, was energy. Physicists also knew that electromagnetic waves carried energy, and they knew that gravity was a source of energy. Both of these were kinds of physical force. Research into particle physics and the use of particle-accelerators uncovered two other kinds of force, both operating at the atomic level: the 'strong' and 'weak' nuclear forces. Thus emerged the theory of the 'four fundamental forces' of nature, a theory that holds today.

The fundamental forces share a number of characteristics. One, they exist as a 'field', that is, as producing a certain force (or, more generally, 'action'[9]) in the surrounding space.

Two, the forces are manifest by *the exchange of particles*; each force has its own associated particle that acts as the carrier of that force (see below). Three, each force is non-linear with respect to distance from its source. In addition, the two forces responsible for all large-scale phenomena — gravity and electromagnetic — have the property of decreasing in strength as distance increases, asymptotically approaching, but *never reaching*, zero. This fact is important in the larger conception of the Partimater.

To summarize: In the current theory, energy exists in two basic forms: 'mass' (i.e. rest mass), and 'force':

1) Mass — the energy in a quantity of rest mass (m) is = mc^2

2) Force — 4 fundamental forces, each carried by a particular 'force particle':
   (a) electromagnetic - transmitted by the 'photon'
   (b) gravity - transmitted by the 'graviton'
   (c) strong - transmitted by the 'gluon'
   (d) weak - transmitted by the 'intermediate vector boson'

So, our modern mass-energy picture of physical reality is *entirely particle-based*: two particles of mass (leptons and quarks), and four particles of force — six total. These six types of particles account for the *whole of materialist reality*. Leucippus and Democritus stand vindicated. Furthermore, the mass particles have the potential of being converted entirely into energy, via collision with each one's anti-particle. In this view — that of Einstein and Russell, among others — we really have just particles of energy; a fulfillment of the energeticist dream.

Around the turn of the century, three other significant developments emerged. I mention these only in passing now, but I will return to them later. First: A new concept came into being which added further complications to the mass-energy worldview, and this was the *quantum*. Energy was packaged not in arbitrary units, but as multiples of a small base unit. Atoms which changed energy levels did so not smoothly and continuously, but in discrete jumps. Furthermore, particles obeying quantum mechanics exhibited strange new properties, that were statistical, unintuitive, and even paradoxical in nature.

Second: As it happened, certain philosophers of science were unhappy with the quantum mechanical, mass-energy picture. Even as the relativistic concepts were emerging, people like William Kingdom Clifford were proposing alternative theories of reality. Clifford put forth the notion that particles of mass were in essence 'wrinkles', or in his words, "hills", of space-time itself. This theory was taken up in the 1960's by Wheeler, in his concept known as 'geometrodynamics'.

Third: Another new approach had opened up in the late 1800's, and this was due to Bergson. He saw *time* as an essential feature of reality, and developed philosophical implications from the new concept of space-time. For Bergson, the classical picture of inert matter sitting 'in space' and 'in time' was fundamentally flawed. With the unity of space and time into space-time, it became clear to him that matter could never be independent of time. Matter must have a 'temporal nature' at root. And, the persistence of matter could be explained only by presuming an element of *memory* within matter; somehow, information from the immediate past had to be carried over to the unfolding of the future, otherwise persistence and unity over time would be impossible. Bergson's insights were supported by advances in physics: de Broglie discovered the 'oscillatory' description of matter, and Heisenberg's "uncertainty principle" showed, in its alternative formulation, that energy and time were inextricably linked.

Bergson's ideas were endorsed by James, and taken up by Whitehead (and later Bohm), who developed what is now referred to as 'process philosophy'. This view sees neither mass nor energy as fundamental, but rather something called an "event". Reality and the persistence of matter are seen as an unending series of events in space-time, involving energy but not consisting of energy. Events are thus seen as the true realities, and, as Capek states bluntly, "particles and motions *do not exist*" (1961: 391). So much for the idea of 'things that move'.

Here, I will adopt essentially an energeticist view *with respect to the physical world*. I take energy as the fundamental material substance, but with the provision that energy only represents one of two (at least) aspects of a total monistic reality. 'Particles' I take as intense, quasi-stable concentrations of energy. Furthermore, in the post-Newtonian era it is easier to disregard the classical notion of particle than it is of 'motion'; motion seems to be essential to the process of exchange and participation. And motion, of course, necessarily involves a concept of time, so the distance between a strict 'process' view of reality and modern energeticist/physicalist view is perhaps not so great as Capek suggests.

NOTES:

[1] Cf. Mautner (1996: 198), or Laurita (1989: 79).

[2] This makes Anaxagoras a metaphysical idealist, though not the first; Parmenides held that Being was identical to Mind -- ref Chapter 1.

[3] The later atomist Epicurus (342-270 BCE) is generally attributed with popularizing the idea of atoms 'falling through the void'.

[4] Five, if we count 'the aether' of the heavens.

[5] Cf. Laws, X, 898d; and also see my later discussion.

[6] They used the term 'force', which only adds to the confusion, but from the context it is clear that they are referring to the concept of energy.

[7] From Schelling's work, *Einleitung zum Entwerf eines Systems der Naturphilosophie* (1799), cited in Jammer (1972: 514).

[8] Rankine and Helm also played a role in the development of energeticism.

[9] In particular, the weak force is not really a force in the classical sense. Rather, it only affects decay rates of atomic particles. This contrasts to the traditional action of a force as producing an acceleration of some mass.